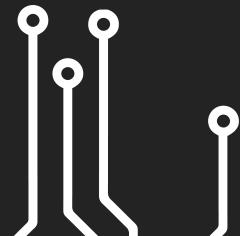
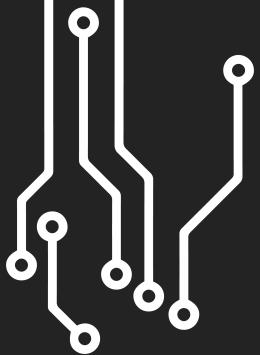


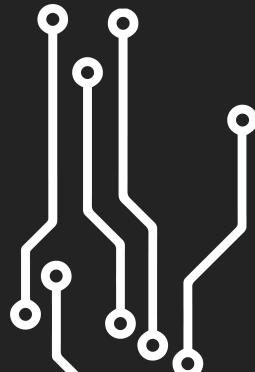
# COTS Parts Introduction





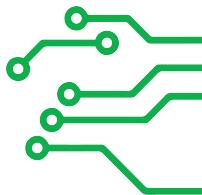
We will be discussing COTS for both  
FRC and FTC

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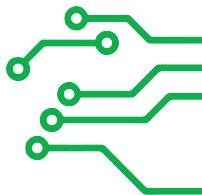
# What are COTS Parts?

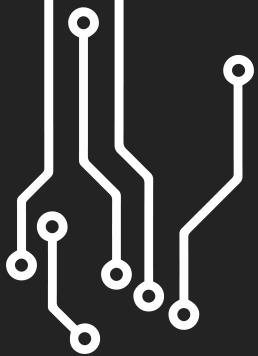
- Commercial Off Ithe Shelf
- Must be available to all teams
- Provided by a Vendor
- Cannot be modified\*
- Creates level playing field



# Types of COTS Parts

- Mechanical
  - Wheels, Chain, Gearboxes, Bearings
- Electrical
  - Motors, Linear Actuators, Servos
- Pneumatic
  - Cylinders, Solenoids, Manifolds
- Control Systems
  - RoboRIO, PDP, VRM, etc.

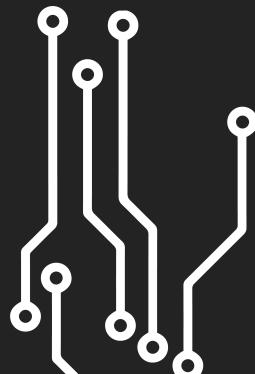




# Mechanical

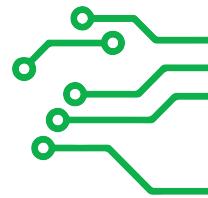
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COTS Parts for Movement



# Wheels

- Movement
- Intake of Game Pieces
- Manipulation of Game Pieces
- Launching of Game Pieces

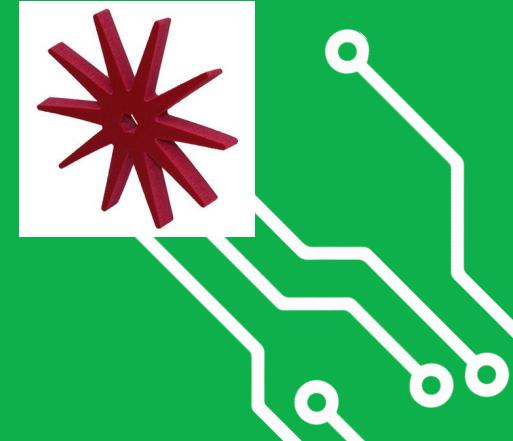


# Examples

- Drivetrain (Robot Movement)

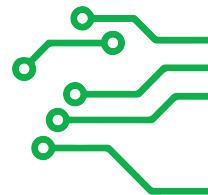


- Intake/Manipulation



# Gearboxes

- Reduction in Free Speed
- Increase Available Torque
- Reduce Motor Power Needed
- Driveshaft Conversion



# Main Drive Gearboxes

## Single Speed Gearboxes

- Have one available overall reduction
- Less Mechanically Complex
- Cost Less
- Are a Closed System

## Dual Speed Gearboxes

- Have two available overall reductions
- More Mechanically Complex
- Cost More
- Not a Closed System; Relies on Pneumatics to Work Reliably

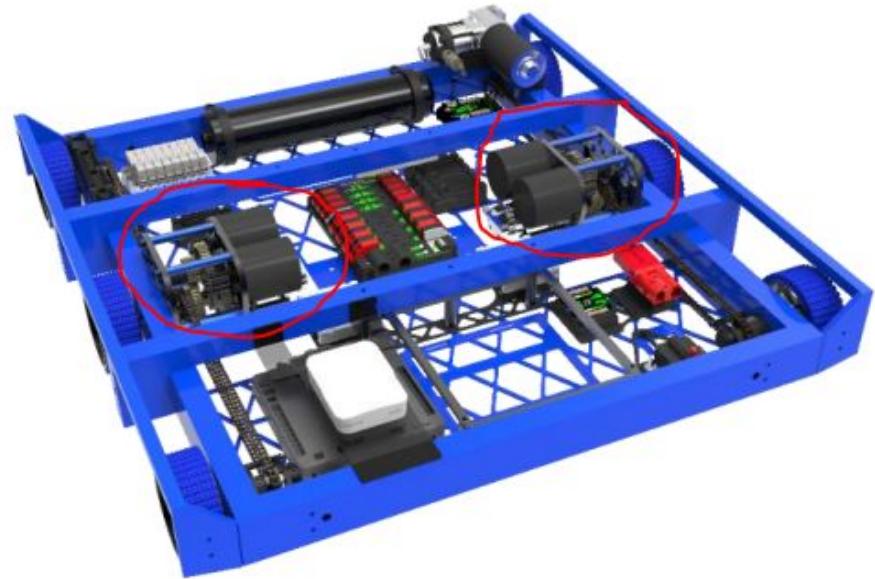
# Main Drive Gearboxes Cont.

Single Speed Gearboxes

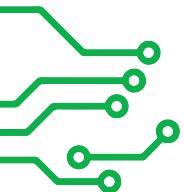


Dual Speed Gearboxes



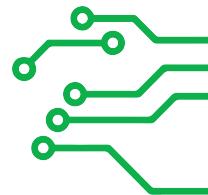


# Use Case Example

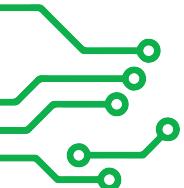


# Planetary Gearboxes

- Allow for streamlined, low profile gear reductions
- Generally for Applications Where Space is a Limiting Factor
- Wide Range of Reductions



# Examples



- VersaPlanetary Gearboxes

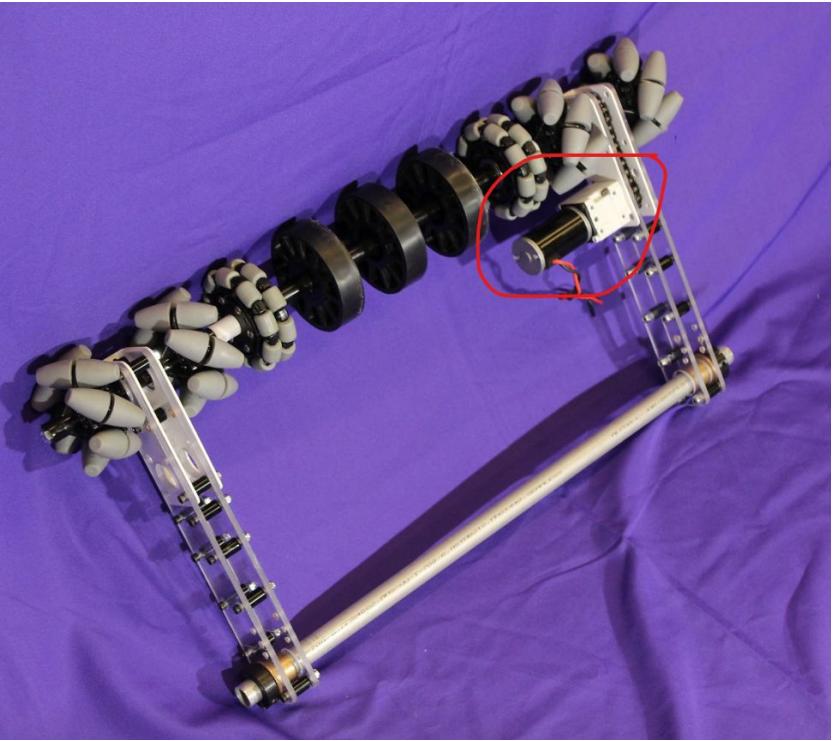


- BaneBots Planetary Gearboxes



- AM GearMotors



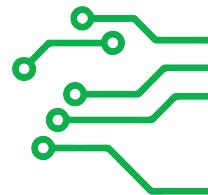


# Use Case Example



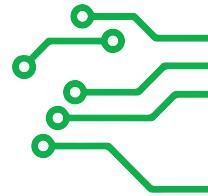
# Power Transmission

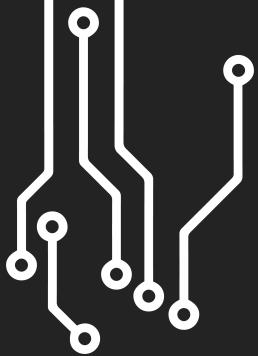
- Chain; Two FRC Sizes (#25 & #35)
- Timing Belts
  - Measured in MMs Width
- Smooth Belting
  - Can be tons of different materials



# Bearings

- Reduce friction for rotating surfaces
- Provide a structural mounting point for shafts being lifted
- Come in round, hex, and keyed variants for FRC

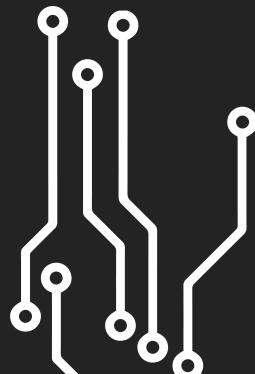




# Electrical

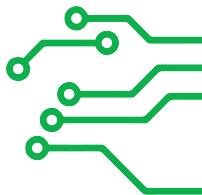
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COTS Parts for Power



# Motors

- Used to create rotational motion
- Have different use cases dependent on loads needed to move
- Brushed and Brushless
- Provided by many different vendors



# Brushed vs. Brushless

## Brushed Motors

- Simpler in construction
- Weigh More
- Older (more support within FRC)



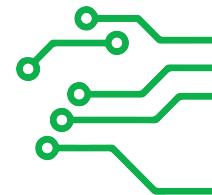
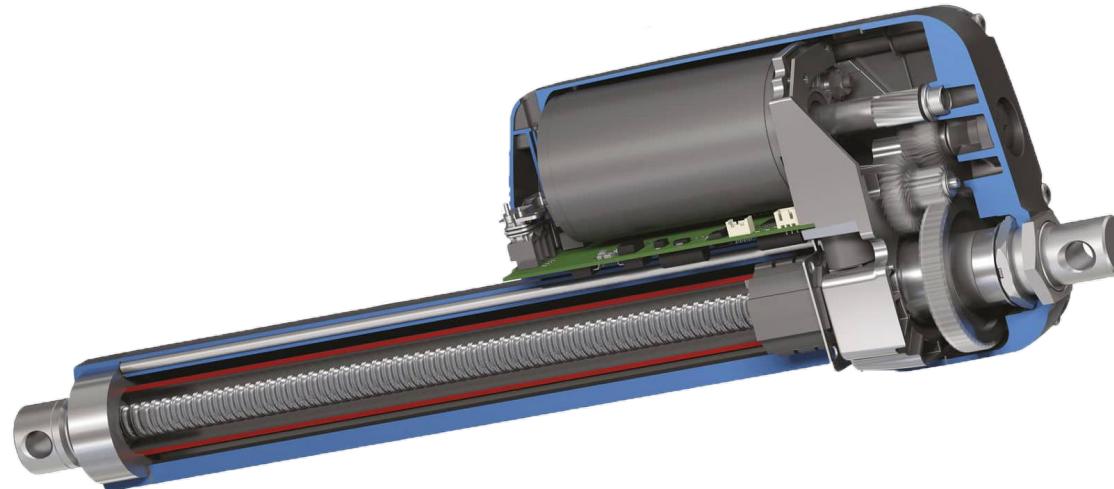
## Brushless Motors

- More complex construction
- Weigh Less
- Newer (less accumulated knowledge)



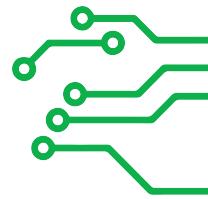
# Linear Actuators

- Electrical Linear Motion
- Allow for precise control for linear motion

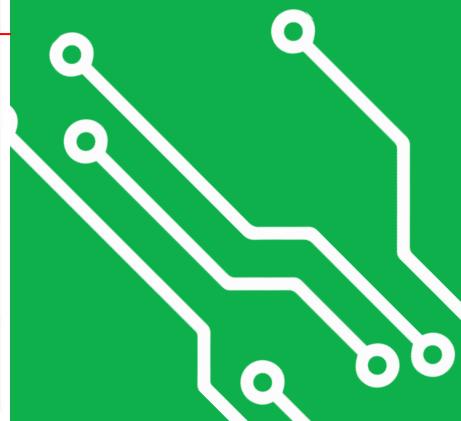


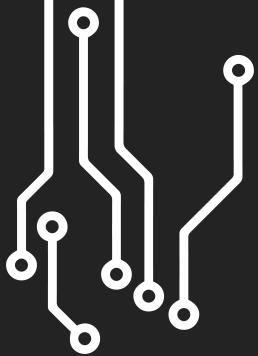
# Servos

- For precise rotational movement
- Predefined range of motion



		Free Speed (RPM)	Free Current (A)	Maximum Power (W)	Stall Torque (N · m)	Stall Current (A)
Falcon 500		6380	1.5	783	4.69	257
NEO Motor		5880	1.3	516	3.36	166
CIM Motor		5330	2.7	337	2.41	131
Mini CIM Motor		5840	3	215	1.41	89
BAG Motor		13180	1.8	149	0.43	53
775pro		18730	0.7	347	0.71	134
AndyMark 9015		14270	3.7	134	0.36	71
AndyMark NeveRest		5480	0.4	25	0.17	10
AndyMark RS775-125		5800	1.6	43	0.28	18
BaneBots RS-775 18V		13050	2.7	246	0.72	97
BaneBots RS-550		19000	0.4	190	0.38	84

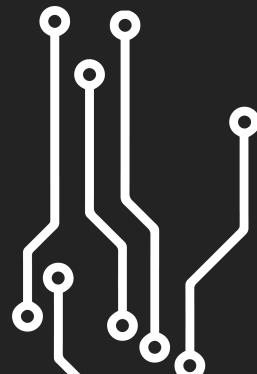




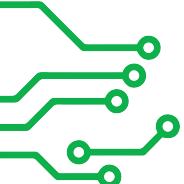
# Pneumatics

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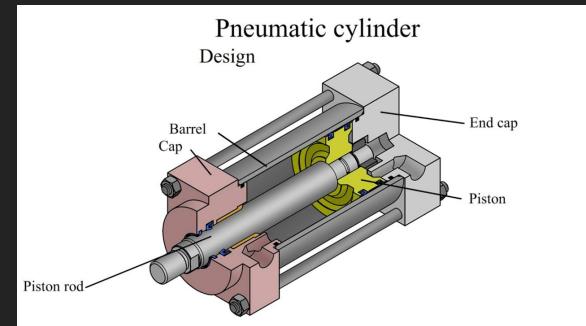
COTS Air Powered Parts



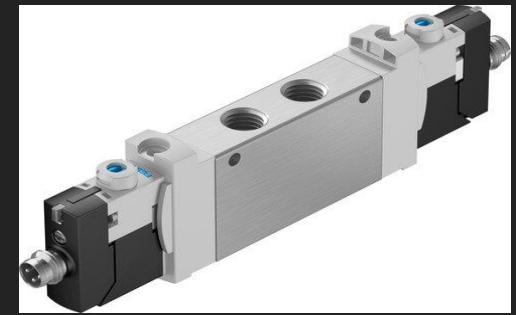
# Pneumatic Components



- Cylinders



- Solenoids



- Air Tanks



# Pneumatic System

Compressor



Safety release valve

Air Tanks



Pressure Gauge  
(working press)



Regulator

Pressure Gauge  
(high press)



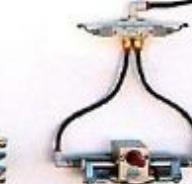
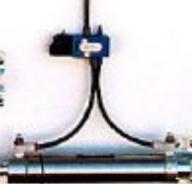
Pressure switch and vent

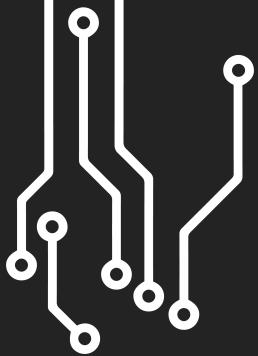
Solenoid

(2 Festo Valves  
are supplied in kit.)



Actuator

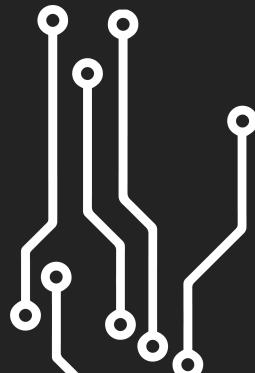




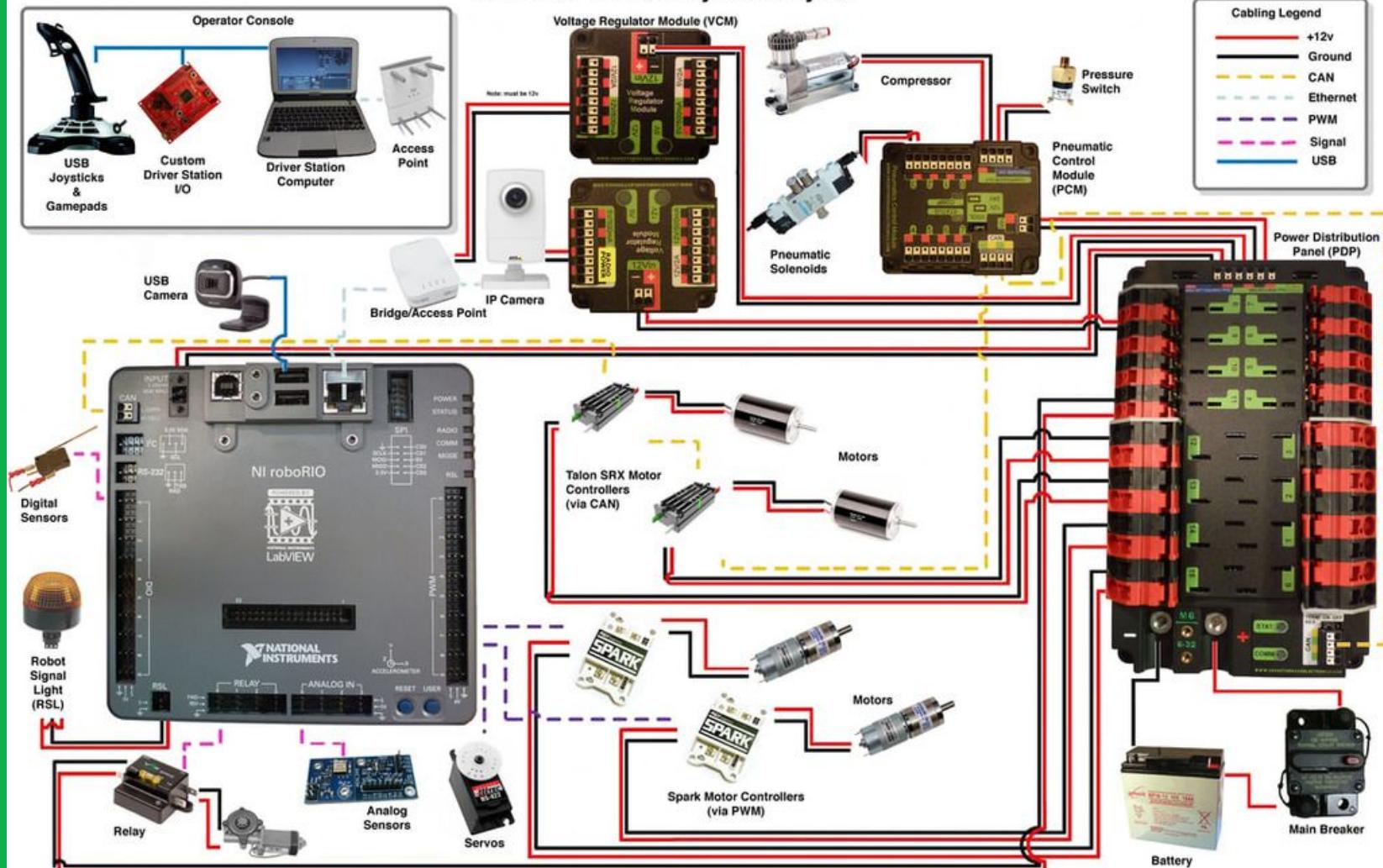
# Control System

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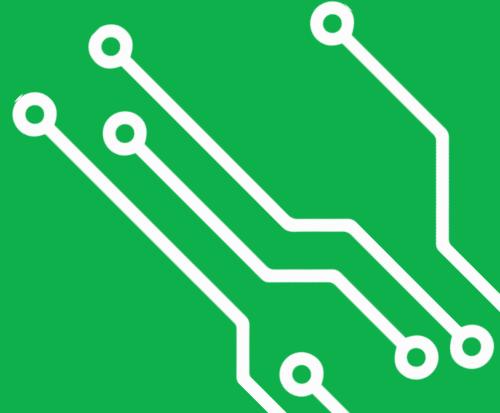
COTS that Make Robots  
Come to Life



# 2017 FRC® Control System Layout



# FTC COTS

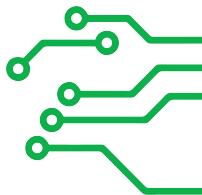


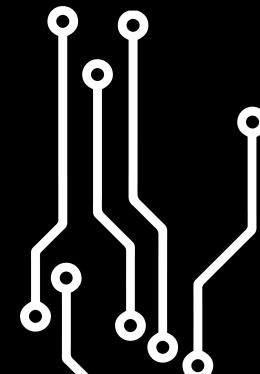
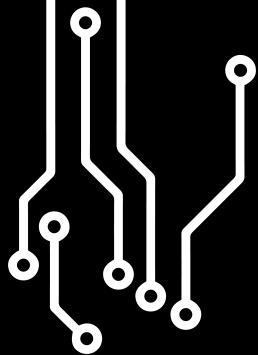
# Brands

FTC uses a variety of brands, and we will be going over each one.

Brands:

- REV
- Tetrix
- Actobotics/Servocity
- goBILDA
- Andymark





# REV Robotics

REV is our go-to company for parts due to the versatility of their build system and their wide range of electronics for FTC.

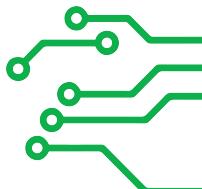


## REV extrusion

Shape allows for screws to be fastened anywhere on the part.

They use the metric system, which is a godsend to CADers (We love you REV)

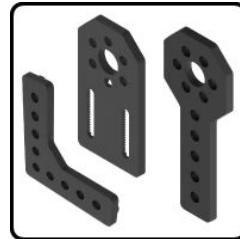
<https://www.revrobotics.com/ftc/>



# REV Structure

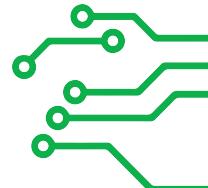
Standard fastener:  
metric M3 bolt + nut

Extrusion is secured using plastic & metal brackets.  
Brackets are secured using M3 hardware (screws, bolts etc)



## FACT:

M3 means that the shaft diameter of the screw is 3 mm!



# REV Electronics

## The Brains



The new control hub is the Brains of your FTC robot. Unlike previous seasons, the control hub no longer needs a phone to wirelessly connect with the driver station. An expansion hub can be used in conjunction with the control hub to expand the capabilities of the control hub



### 12V Battery

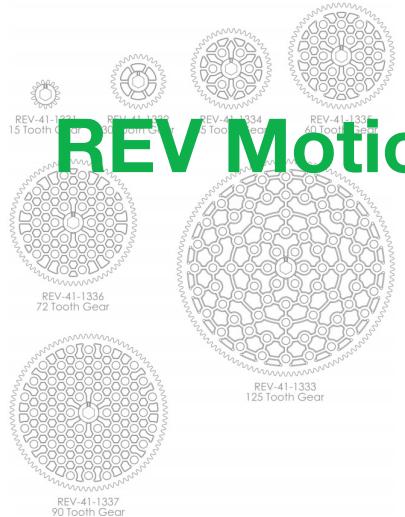
Directly connects with control hub. Remember to use a grounding strap! Please....



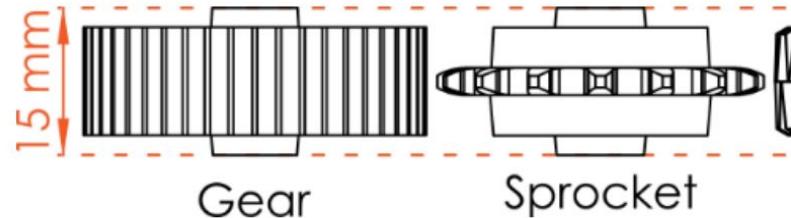
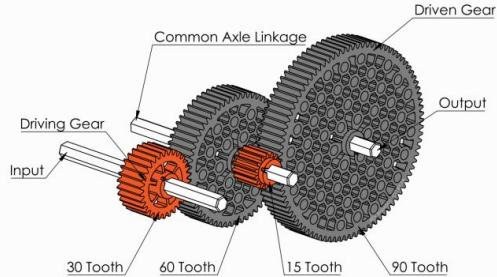
### Sensors

Each sensor hooks into the analog ports of the control/expansion hub and can be read and adjusted through code

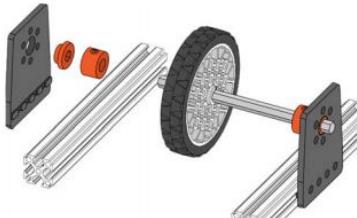




# REV Motion

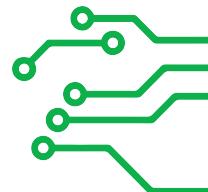


**Standard REV Axle:**  
5mm Hex shaft



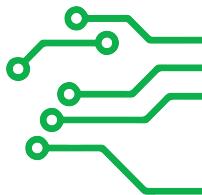
Advantage of Core Hex Motor:

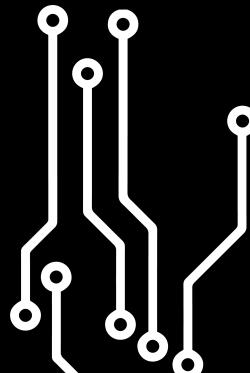
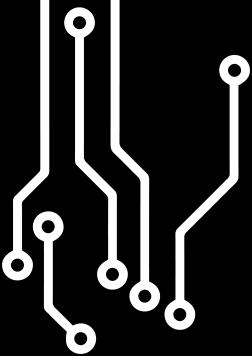
The rotation is perpendicular to the main body of the motor.  
This is useful for saving space in some situations



# REV Summary

Pros	Cons
The expansion hub / control hub are easy to use and are used by most FTC teams, proving their robustness	REV Support is slow and annoying to deal with.
Most parts are inexpensive compared to other build systems	Due to being metric, compatibility with other build systems is difficult, but manageable

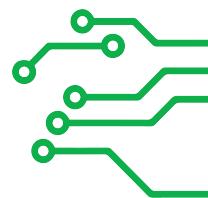




# Tetrix

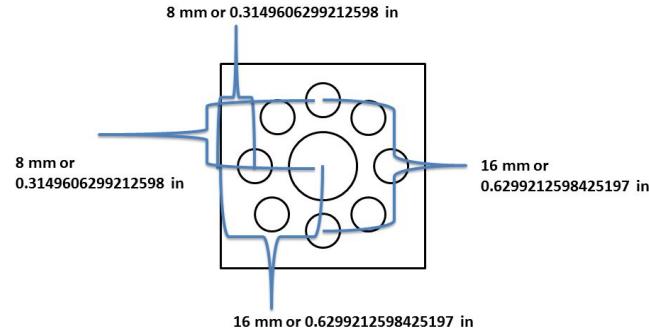


- Outdated
- Rigid/limits customizability
- Legacy FTC system
  - Many teams still use it
  - We even have spare parts that are tetrix

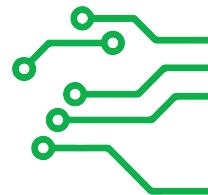


# Tetrix Structure

- When building with tetrix, you are limited to this repeating pattern
- Pattern is metric
- Motors are mounted with clamp mount
- Their fastener, however, is imperial (don't ask)



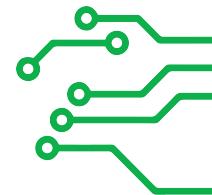
**FASTENER SIZE:**  
**(6-32)**  
**socket: 7/64" hex**



# Tetrix Motion

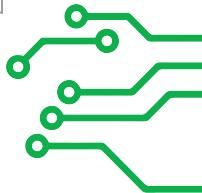


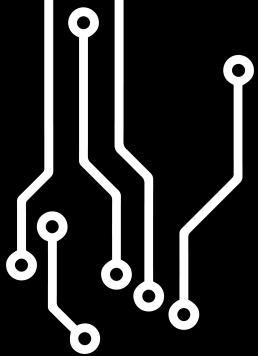
- Main Motor: torquenado
  - Useful High torque motor
- Tetrix also provides many gears, sprockets, and other potentially useful hardware/electronics



# Tetrix Summary

Pros	Cons
Parts are relatively Inexpensive	Channel system is simple and restricts customizability
Tetrix is metric-based	The electronics are outdated and limited in capability
There is a wide variety of structural components	



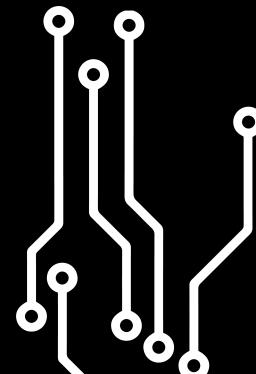


SERVOCITY<sup>•COM</sup>

ACTOBOTICS

DREAM • DESIGN • BUILD • REPEAT

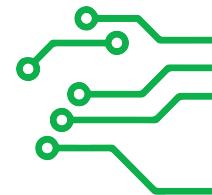
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# Actobotics

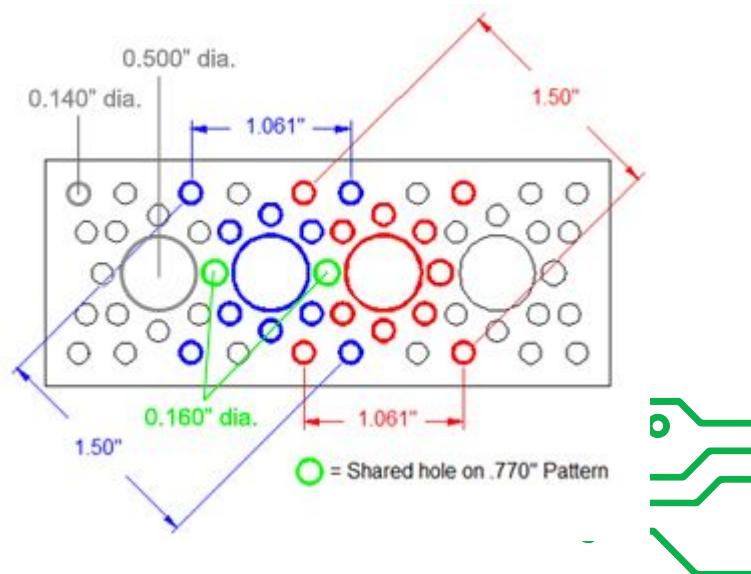
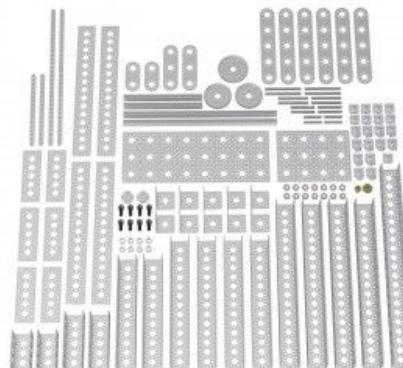
Sold by Servocity, Actobotics is a imperial build systems good for beginner and veteran teams alike.

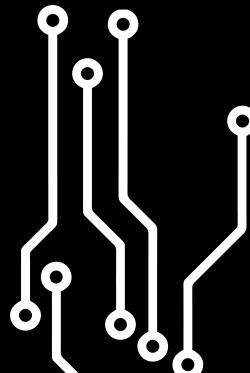
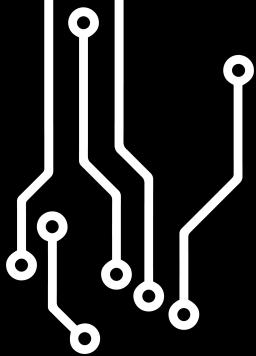
They sell an assortment of parts, specializing in structural parts, such as x-rail and extrusion with a premade pattern.



# Actobotics Structure

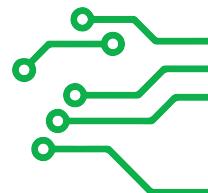
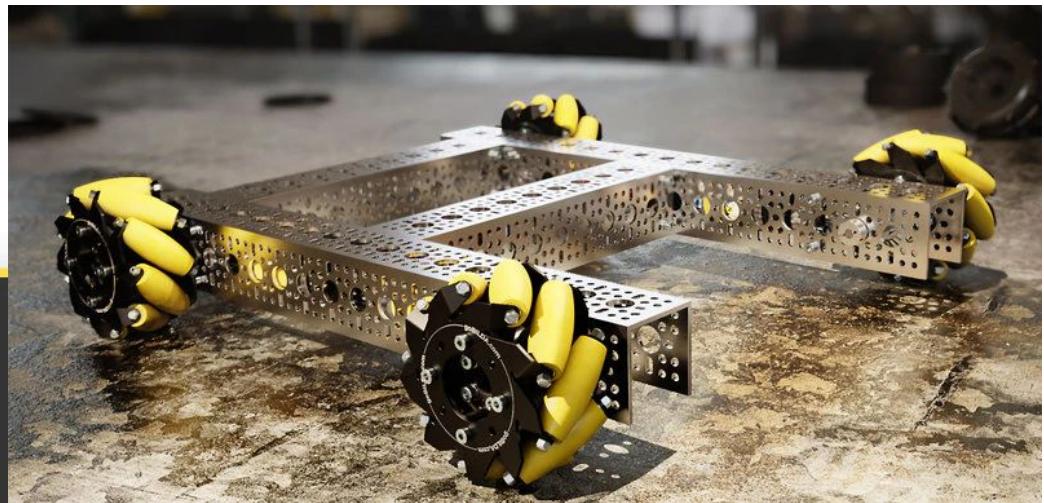
- Whole different build system
- The channel is imperial, measured in inches
- Their system is ball-bearing based, so motion is very smooth



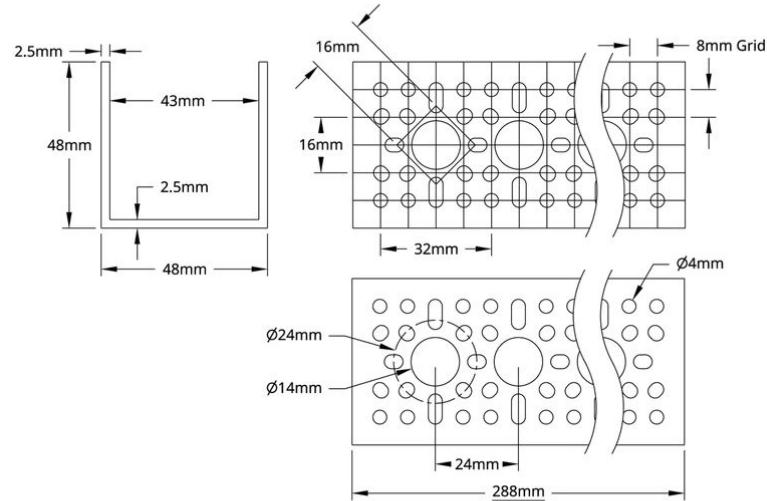


# GoBilda

Gobilda is a high-end robotics company. They sell high-quality parts with very sturdy design in beautiful metric format.



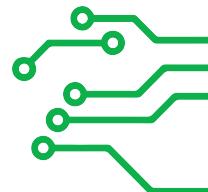
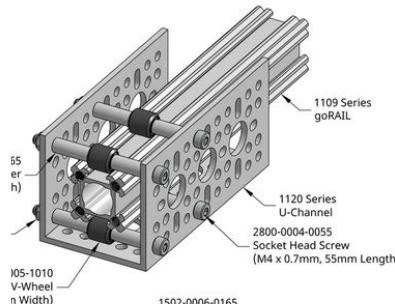
# GoBilda Structure



Their Channel system is compatible with many other metric robotics systems like Tetrix.



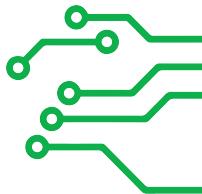
**FASTENER: M4 (4mm dia.) , 3mm socket**



# GoBilda Motion

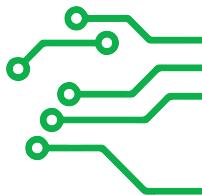


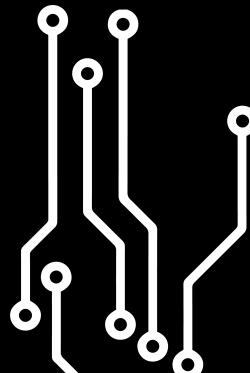
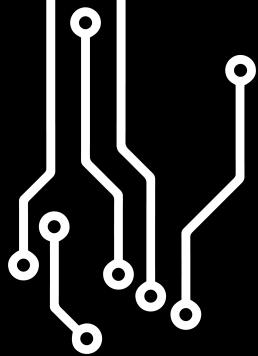
- The yellow jacket is a very high quality, efficient motor
- GoBilda Mecanum wheels are the best quality Mecanums in FTC
- A lot of their motion is bearing-based, so assemblies with gobilda are smooth and sturdy!



# GoBilda Summary

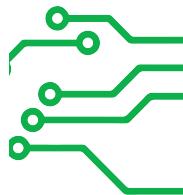
Pros	Cons
Parts very high quality	Oh boy \$\$\$
Ball bearing-based assembly	
There is a HUGE variety of structural components	



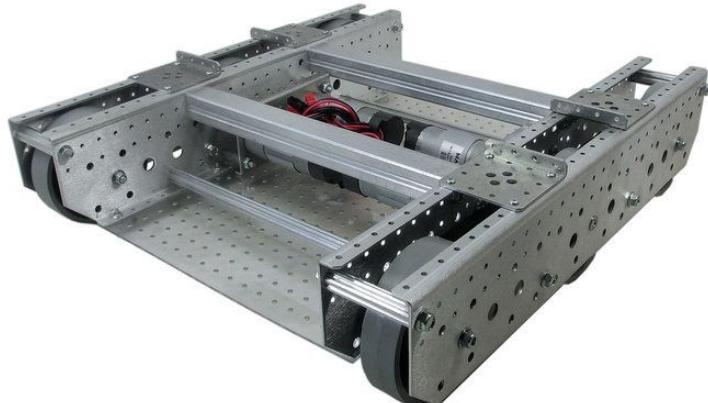


# AndyMark

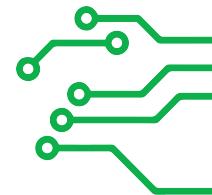
- Mostly an FRC part supplier
- Provides many useful parts but does not provide enough for a full robot
- Accessories like reliable motors, compliant wheels, and various brackets
- They sell FTC fields and replacement game elements



# AndyMark Structure

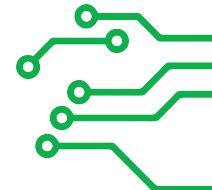
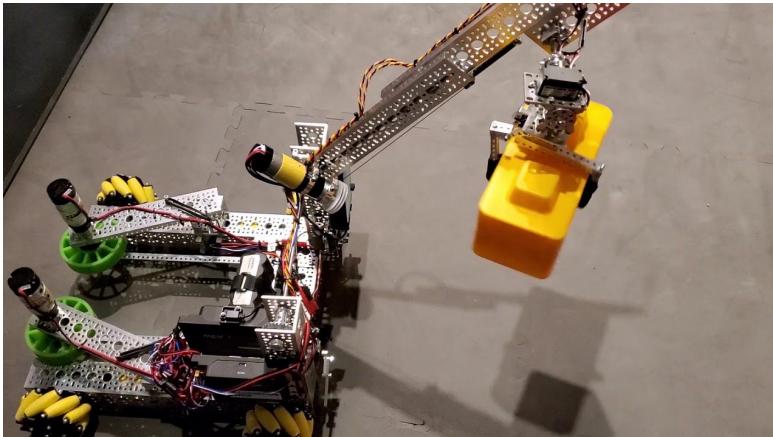


- Andymark sells a variety of chassis called “TileRunner”
- They also sell motor mounts for their respective NeveRest motors



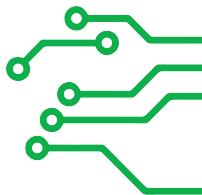
# AndyMark Motion

Their Compliant wheels are the extremely popular because of their material and flexibility. This allows for easy intake of most game elements when you attach them to the front of your robot.

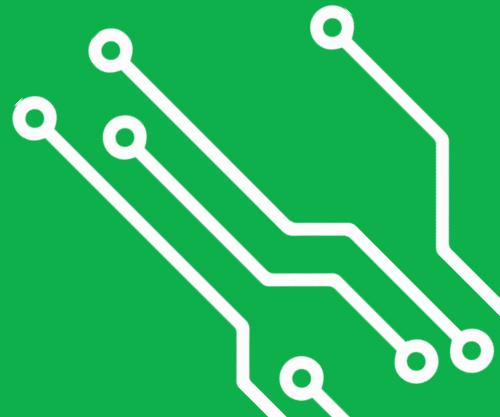


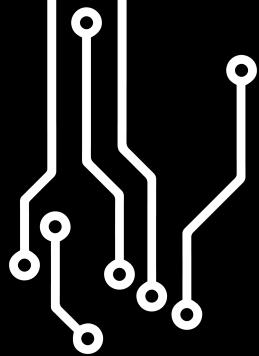
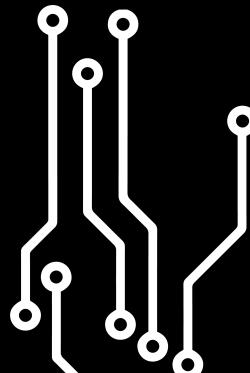
# AndyMark Summary

Pros	Cons
NeverRest Motors	Limited FTC parts
Compliant Wheels	



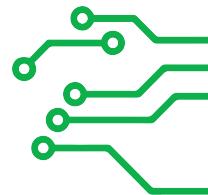
# FRC COTS Suppliers





# About VEXpro

- <https://www.vexrobotics.com/vexpro>
- Developed by FRC mentors (thanks 148)
- Ecosystem designed to raise competitive floor of lower-resource teams



# VEXPro Ecosystem- Good! But Expensive!

## The VersaFrame System

The VersaFrame system is an entire collection of products designed to eliminate frustration and make advanced designs available to all teams. By utilizing modular, low-cost construction components, teams can build almost anything they can think of - and they can do it with only a drill and a wrench.

When VersaFrame was first introduced, it consisted of aluminum tubing and gussets that were pre-drilled on a 1" pitch. By taking design cues from the popular VEX EDR and VEX IQ construction systems, VersaFrame allowed teams to quickly move a design from concept to reality without being hindered by precision manufacturing constraints. Teams could focus on the core of the engineering design process - not the finer details of how to use expensive machinery.

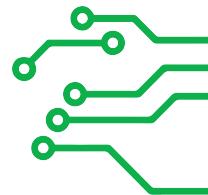
For experienced teams with plenty of resources, this meant quicker prototyping and concept realization. For teams without access to advanced resources, this meant a chance to create sophisticated mechanisms at a fraction of the cost.

Since then, VersaFrame has transcended its initial role as a "set of gussets and tubes". It has become an entire design methodology; a cohesive family of products that work together in simple, intuitive ways to help all teams achieve superior performance.



# VEXPro Ecosystem- Thunderhex

- Round shafts are no fun... hex shafts are better
  - Thunderhex are even better because they will fit in a 1/2" hex bearing and have a hole that can be tapped for a 1/4" bolt!

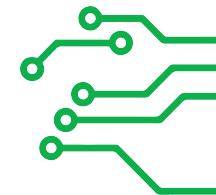


# VEXPro Ecosystem- VersaPlanetary

- VEX has some very good gearboxes for both CIM and brushless motors
- VersaPlanetary
  - Recommend for most everything besides drivetrains/brushless motor applications!
  - Can fit a variety of brushed motors (CIM, 775)
  - Can stack stages together to get a variety of gear ratios
  - <https://docs.google.com/viewerng/viewer?url=http://link.vex.com/vexpro/pdf/VersaPlanetary-LoadRatings>

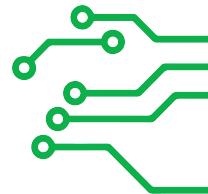


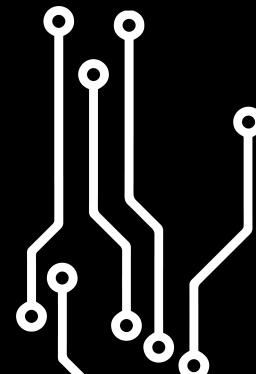
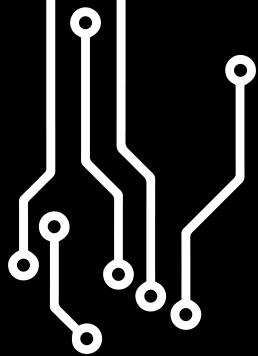
Motor	Stage 1	Stage 2					
		3:1	4:1	5:1	7:1	9:1	10:1
Mini CIM	3:1	9	12	15	21	27	30
	4:1	12	16	20	28	36	40
	5:1	15	20	25	35	45	50
	7:1	21	28	35	49	63	70
	9:1	27	36	45	63	81	90
	10:1	30	40	50	70	90	100



# Other VEXpro uses

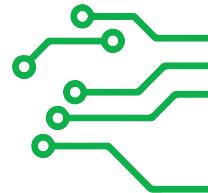
- Good general supplier for FRC parts
  - Hardware (bearings, shafts, spacers, etc... extremely useful for hex shaft parts)
  - FRC electronics
  - Pneumatics (no cylinders though)





# About CTRE

- <http://www.ctr-electronics.com/>
- Electronics suppliers that provide good power/control applications
- Useful components for us:
  - Motors
  - Sensors
  - FRC control system parts
  - Development panels



# CTRE Falcon 500

- Brushless motor
- \$140
- Introduced in 2020
- Built in encoder and controller
- Good for drivetrains, other high-power applications

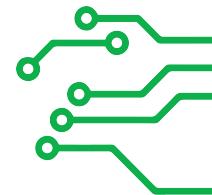
FALCON 500 POWERED BY TALON FX

P/N: 19-708850

Availability: **Out of stock**  
\$139.99

**Quick Overview**

The Falcon 500, powered by Talon FX, is a brushless motor with an integrated controller co-developed through a collaborative partnership between VEX Robotics and Cross the Road Electronics.



# CTRE Sensors

- SRX Magnetic Encoder / CANcoder
- Pigeon IMU

**SRX MAG ENCODER**

P/N: 15-697867



Availability: **In stock**

\$39.99

Qty:  [Add to Cart](#)

-OR-

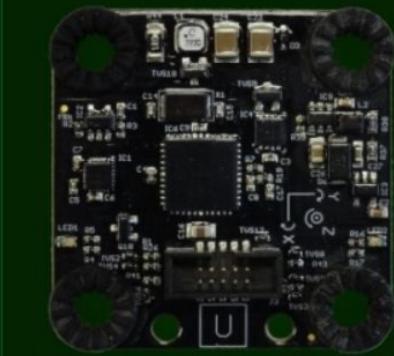
[Check out with PayPal](#)

**Quick Overview**

The SRX Mag Encoder is a rotary sensor that can be used to measure rotational position and velocity.

**GADGETEER PIGEON IMU**

P/N: 16-737785



Availability: **In stock**

\$59.99

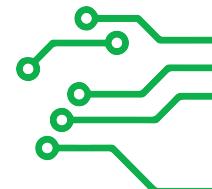
Qty:  [Add to Cart](#)

-OR-

[Check out with PayPal](#)

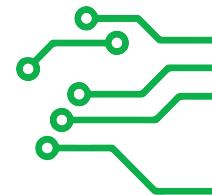
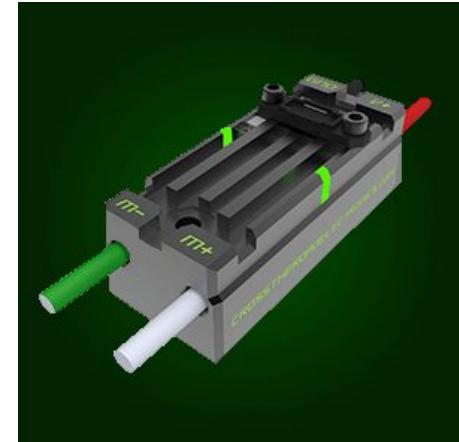
**Quick Overview**

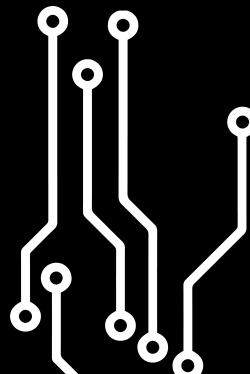
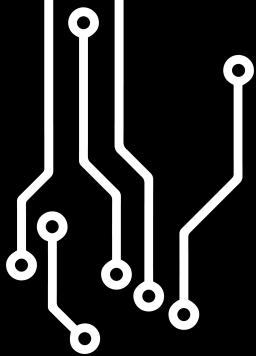
Pigeon is an IMU with 9 degrees of freedom, containing a 3-axis magnetometer, accelerometer, and gyro. This device ships with a 4" gadgeteer data cable.



# CTRE Control System Components

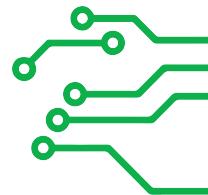
- Core Electronics
- Motor Controllers
  - Talon SRX (\$90) / Victor SPX (\$50)
- HERO Development Board (\$60)
- IMU (\$60)
- Other fun things :)





# About REV

- [www.revrobotics.com](http://www.revrobotics.com)
- General robotics supplier (does a lot for FTC)
- Useful components for us:
  - Neo Motor
  - Electronics
  - Lift kit... kinda

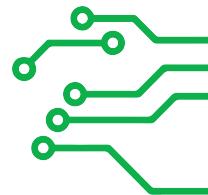


# Neo Motor

- Brushless motor, useful for high power applications you don't want to use a Falcon for
- Must be used with the Spark MAX controller
- Total: \$115



FRC Legal

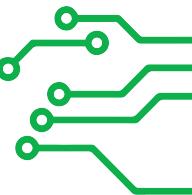


# Electronics

- Things I find useful:
  - Hex shaft encoder (\$30)
  - MXP accessories (\$5-\$45)
  - Sensors (pressure transducer, magnetic, distance, etc.)



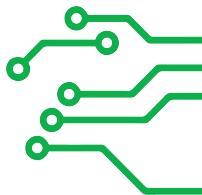
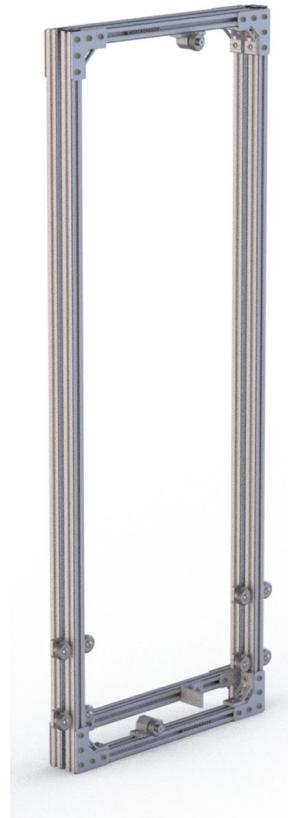
FRC Legal

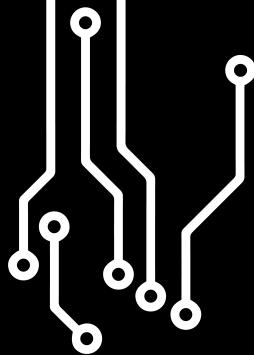


FRC Legal

# Lift Kit

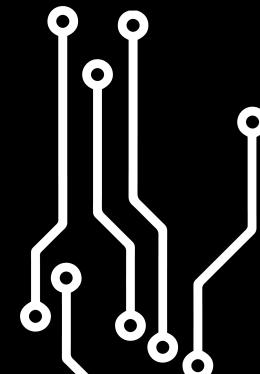
- Good COTS solution to build an elevator
- Kinda overpriced, but the system is good to know about
  - By understanding how this works, you can design your own lift!





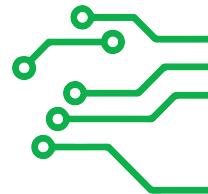
WESTCOAST PRODUCTS

ADVANCING PERFORMANCE



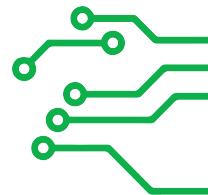
# About WCP

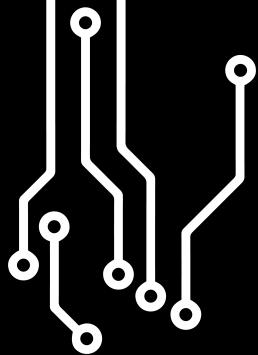
- <https://www.wcproducts.com/>
- West Coast Products (like WCD...) good drivebase / motion supplier
- Useful components for us:
  - Gearboxes
  - Motion Components
- Alternate supplier for VEX parts.. Often can order from here instead



# West Coast Gearboxes

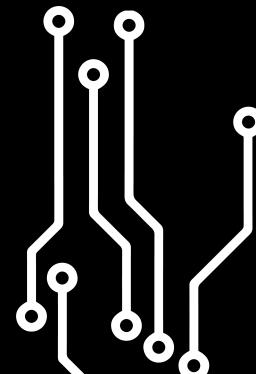
- Very popular gearboxes for use in FRC
  - Gearboxes for brushed and brushless motors
- Come in 2 and 3 motor variants with a variety of gear ratios
- Dual Speed / Swerve COTS components available as well
- A bit pricey.. Be prepared to spend \$100+ per gearbox without motor





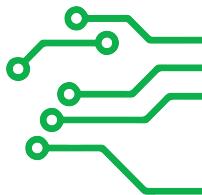
**McMASTER-CARR.**®

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# About McMaster-Carr

- <https://www.mcmaster.com/>
- General parts supplier, a bit more pricey than elsewhere but good quality + ships fast!
- Useful for us:
  - Raw materials (plastics, metals)
  - Hardware
  - Electrical
  - Tools / PPE / general shop stuff
  - Pretty much any general part...
- Seriously. Take a look at their site



# McMaster.. Just 3 of 28 different sections!

## Fastening & Joining

### Fasteners



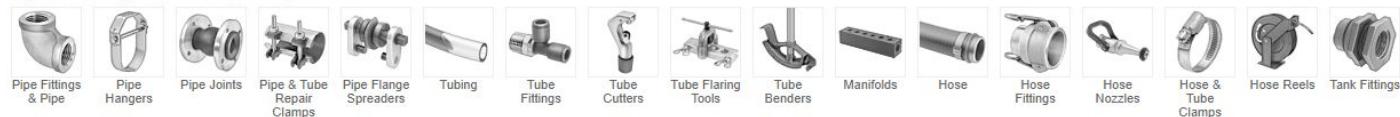
### Adhesives & Tape



### Welding, Brazing & Soldering



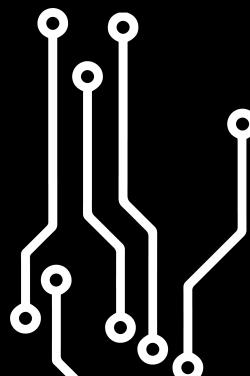
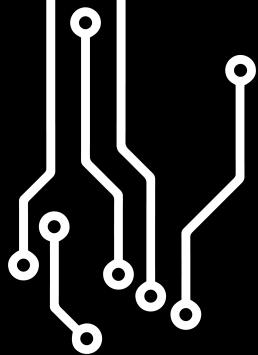
## Pipe, Tubing, Hose & Fittings



## Power Transmission

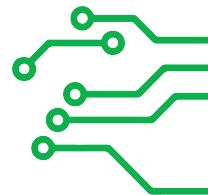
### Rotary Motion





# About Bimba

- <http://www.bimba.com/>
- Pneumatics Supplier
- Useful components for us:
  - Pneumatic cylinders!



# Original Line

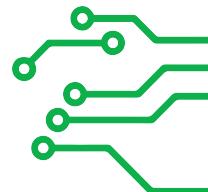
- Can be customized to a bunch of different lengths/sizes [0.011" - 50" in 0.001" increments]
- Definitely use double-acting, lots of different mounting options though depending on application

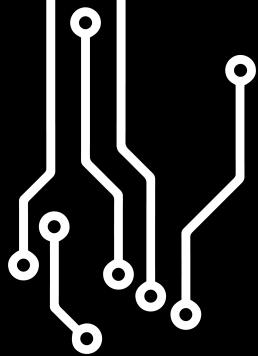


## Original Line® Air Cylinder

The newly redesigned "Blue and Improved" Original Line® air cylinder now features permanent grease lubrication. This product line includes standard air cylinders, three-position air cylinders, MRS air cylinders, non-rotating air cylinders, and PC air cylinders. Design enhancements to this line have more than doubled the anticipated service life of this industry-leading, non-repairable family of air cylinders.

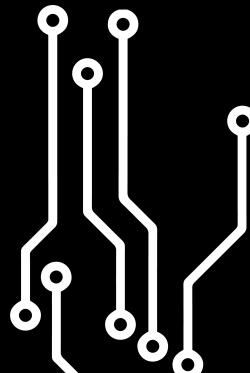
- Bore sizes: 5/16", 7/16", 9/16", 3/4", 7/8", 1 1/16", 1 1/4", 1 1/2", 1 3/4", 2", 2 1/2", 3"
- Wide variety of stroke lengths and mounting styles
- Over 150,000 Original Line® cylinders are inventoried and ship same day
- Bimba can manufacture any catalog model in four days or less
- Blue and Improved design doubles previous cylinder life
- Permanent grease lubricant requires no additional lubrication during service





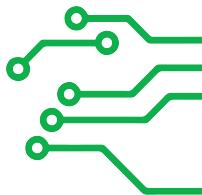
**A** AndyMark®

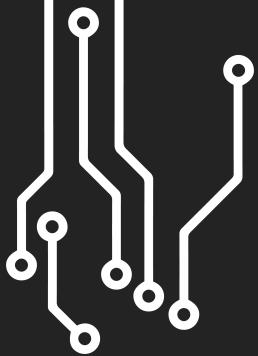
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# About AndyMark

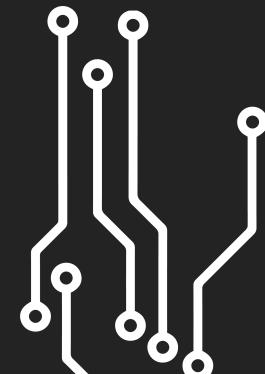
- <https://www.andymark.com/>
- Founded by FIRST mentors, good general supplier
- Products that are useful to us:
  - Control System components
  - Hardware
  - Gearboxes





# CAD with COTS

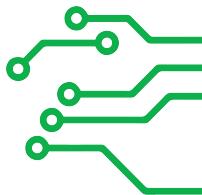
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# Why

Many of these brands provide CAD files for their parts. These files are extremely useful in designing for the parts, as you don't have to manually model the parts in order to use them.

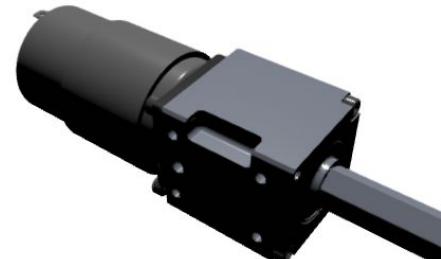
Having these on hand helps you quickly see your mechanisms come together with accurate motors, etc! Not to mention its very useful to know how to do mounts for motors, etc..



# How To

- Look on the website for .step files
- Download and import it into your CAD program of choice

Description	Kit Contents	Docs & Downloads	Material Type	Material Finish	Drawing	Weight	Other Info	CAD Files	
VersaPlanetary v1 Single Stage 10:1 with BAG									
VersaPlanetary v1 Single Stage 10:1 with RS 550									
VersaPlanetary v1 Single Stage 10:1 with 775 Series									
VersaPlanetary v1 Single Stage 10:1 with AM 9015									
VersaPlanetary v1 Two Stage 100:1 with BAG									
Example v2 Gearboxes									
VersaPlanetary v2 Single Stage 10:1 with BAG									
VersaPlanetary v2 Single Stage 10:1 with RS 550									



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